

# MONTHLY WEATHER REVIEW.

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## INTRODUCTION.

The REVIEW for May, 1894, is based on reports from 3,442 stations occupied by regular and voluntary observers. These reports are classified as follows: 153 reports from Weather Bureau stations; 41 reports from U. S. Army post surgeons; 2,324 monthly reports from State weather service and voluntary observers; 31 reports from Canadian stations; 222 reports through the Southern Pacific Railway Company; 588 marine reports through the co-operation of the Hydrographic Office, Navy Department, and "New York Herald Weather Service;" monthly reports from 35 U. S.

Life-Saving stations; 48 reports from navigators on the Great Lakes; monthly reports from local services established in all States and Territories; and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

The WEATHER REVIEW for this month has been prepared under the general editorial supervision of Prof. Cleveland Abbe. The statistical tables are furnished by the Division of Records and Meteorological Data, in charge of Mr. A. J. Henry, acting chief of that division.

## CHARACTERISTICS OF THE WEATHER FOR MAY, 1894.

The most prominent meteorological features of the month of May were the infrequency of areas of low pressure; the general high temperature in the Missouri Valley and northern slope and the low temperature on the Pacific coast; the special cold periods of the 19th, 20th, and 21st from the Missouri Valley to the Atlantic coast, and that of the 16th in Cali-

fornia and Oregon; the large excess of rainfall in the middle Atlantic States and upper Lake region, and on the southern slope of the Rocky Mountains, viz, in eastern Colorado and central Texas; the large deficit of rainfall in the Missouri Valley, the east Gulf and west Gulf regions; the snowfall in Kentucky and Tennessee; the river floods in New York, Pennsylvania, and Washington.

## ATMOSPHERIC PRESSURE.

[In inches and hundredths.]

The distribution of mean atmospheric pressure reduced to sea level, and as shown by mercurial barometers not reduced to standard gravity and as determined from observations taken daily at 8 a. m. and 8 p. m. (seventy-fifth meridian time), during May, 1894, is shown by isobars on Chart II. That portion of the reduction to standard gravity that depends on latitude is shown by the numbers printed on the right-hand border. This Chart also gives the so-called resultant wind directions for this month, based on the data given in Table IX of this REVIEW.

During the current month of May the pressures at sea level have been highest, 30.04, in the extreme western portion of the State of Washington and very nearly the same, 30.03, on the eastern coast of Florida, which two regions represent the borders of the areas of high pressure over the Pacific and Atlantic oceans, respectively. The regions of lowest pressure were in southern Arizona and California, the lowest being 29.78 at Yuma; the next lowest pressures were from 29.85 to 29.83 in eastern Montana and Alberta and western Saskatchewan and Assiniboia.

The normal distribution of atmospheric pressure and normal resultant wind direction for the month of May were approximately shown on Chart VI of the REVIEW for May, 1893, as computed by Prof. H. A. Hazen, and are not

now reproduced. As compared with the normal for May, the mean pressure for the current month was in excess by 0.06 or less in Maine, the Maritime Provinces, and the Gulf of St. Lawrence, as also throughout a region extending from Texas to Washington, and eastward to Iowa and Manitoba. The principal deficits were in Oregon, California, and Arizona, as also throughout the Lake region, the middle and south Atlantic States. The largest deficit was 0.08 at Washington, Baltimore, and Roseburg, and the largest excess was 0.06, at Omaha, Port Arthur, and Anticosti Island.

As compared with the preceding month of April the mean pressure for May was slightly higher on the coast of Nova Scotia, in Oklahoma, Kansas, and the northern part of Alberta, but lower in all other districts. The greatest fall was about 0.15 in northern California, Nevada and Utah, and southern Oregon and Idaho.

The systematic periodic diurnal variations of pressure are shown by the hourly means given in Table VI.

## AREAS OF HIGH AND LOW PRESSURE.

The following sections give some details as to the phenomena attending the individual areas of high and low pressure. The storm warnings officially issued either by the Weather Bureau through the general forecast official at Wash-

ington, or by the respective local forecast officials, are enumerated in connection with the respective areas of disturbance.

#### MOVEMENTS OF CENTERS.

The following table shows the date and location of each center of high or low pressure at the beginning and ending of its appearance on the U. S. Weather Maps, together with the average daily and hourly velocities. The monthly averages are given by paths and by hours.

*Movements of centers of areas of high and low pressure.*

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
<b>High areas.</b>		o	o		o	o	<i>Miles.</i>	<i>Days.</i>	<i>Miles.</i>	<i>Miles.</i>
I.....										
II.....										
III.....										
IV.....	1, a. m.	52	109	4, a. m.	45	59	2,700	3.0	900	37.5
V.....	9, a. m.	43	82	11, a. m.	44	51	1,150	2.0	575	44.0
VI.....	9, p. m.	46	116	12, p. m.	39	73	1,500	3.0	500	20.8
VII.....	12, a. m.	54	106	15, p. m.	43	78	1,900	3.5	543	22.4
VIII.....	17, p. m.	47	105	19, a. m.	49	96	1,000	1.5	667	27.8
IX.....										
X.....	22, p. m.	43	109	24, p. m.	39	102	400	2.0	200	8.3
XI.....	26, a. m.	53	105	29, a. m.	37	80	1,750	3.0	583	24.3
XII.....	30, a. m.	47	91	31, p. m.	42	103	700	1.5	467	19.5
Sums.....							11,000	19.5	4,435	.....
Mean of 8 paths.....									686	28.6
Mean of 19.5 days.....									657	27.4
<b>Low areas.</b>										
I.....	1, a. m.	45	92	2, p. m.	44	67	1,200	1.5	800	33.3
II.....										
III.....	2, p. m.	53	112	8, p. m.	56	62	2,400	7.0	.....	34.3
IV.....	7, p. m.	52	115	10, a. m.	52	85	2,000	2.5	800	33.3
V.....	15, a. m.	46	106	21, a. m.	38	83	2,300	6.0	383	16.0
VI.....	13, a. m.	52	64	15, p. m.	49	53	850	2.5	260	10.8
VII.....	23, p. m.	36	80	26, a. m.	43	68	1,000	2.5	400	16.7
VIII.....	25, p. m.	50	129	29, a. m.	53	105	1,000	3.5	286	11.9
IX.....	26, a. m.	42	103	28, a. m.	47	78	1,250	2.0	625	26.0
X.....	28, a. m.	38	81	29, a. m.	42	72	650	1.0	650	26.3
XI.....										
XII.....	30, p. m.	32	78	31, p. m.	42	70	600	1.0	600	24.2
Sums.....							13,050	29.5	4,804	.....
Mean of 10 paths.....									480	20.0
Mean of 29.5 days.....									442	18.4

#### HIGH AREAS.

I.—This number is given to the area of high pressure that prevails in the tropical portions of the Atlantic Ocean. When this area advances westward so far that its western portion covers the south Atlantic States there prevail steady northeast winds and clear weather in that region near the coast, but southeast winds and clear weather in the interior and southerly winds with clear or hazy weather in the middle Atlantic States. These conditions continued in the south Atlantic States from the 1st to the 4th, the highest pressure being 30.40 on the 1st, a. m., at Wilmington, and 30.14 at Key West, from which readings the pressure diminished steadily until the 5th, a. m., when it was 30.12 at Wilmington and 30.08 at Key West.

These westerly extensions usually result from the southward movement of high pressures along the Atlantic coast or the southeastward movement of areas of clear, dry, cold air and high pressure over the interior of the continent; in either case the high area over the Atlantic receives an addition on its western side, by reason of which the isobars over the Atlantic are extended westward as though the tropical area of high pressure had moved in that direction. The above-mentioned charts of the 1st to the 4th, as also those of the 11th to the 13th, present illustrations of this formation.

II.—This number is given to the area of high pressure on the Pacific Ocean whose eastward extension brings high pressure, northerly winds, and cold, dry weather to the Pacific States, especially when the region of highest pressure lies to

the north of latitude 40°. Illustrations of this action occurred on the 1st and 2d, when the maximum pressure on the coast was 30.42 at Portland, Oreg.; from the 7th to the 10th, when the maximum pressure was 30.46 at Portland, Oreg.; from the 15th to the 18th, when the maximum pressure was 30.20 at San Francisco, on the 15th, and at Portland, Oreg., on the 16th.

The following numbers refer to high areas that were, during at least a portion of their history, wholly within the area of our maps.

III.—This was central in Colorado on the 1st, a. m., and was a branch of high area No. XI from the series for April. It disappeared during the 1st, while the original area of high pressure continued off the Pacific coast, as stated in the above paragraph referring to high area No. II.

IV.—This area appeared on the 1st, a. m., in Saskatchewan and slowly advanced southward; it passed north of Lake Superior on the 2d, and southeastward over the middle Atlantic States on the 3d, where it joined the high pressure of the Atlantic and gave the maximum pressure, 30.40, at Cape Breton on the 4th, a. m.

V.—This began with rising pressure on the 8th over the upper lakes and Ohio Valley; on the 9th, a. m., the highest pressure was central over Ohio and Lake Huron; 9th, p. m., in western New York; 10th, a. m., in the St. Lawrence Valley; 10th, p. m., the Bay of Fundy; 11th, a. m., off the coast of Nova Scotia.

VI.—This began on the 9th, p. m., as an offshoot from the high pressure No. II which was then off the coast of Oregon. The central highest pressure was then in Idaho; it moved southeast to Kansas, thence eastward over Illinois, the lower Lake region, the middle Atlantic States and disappeared on the 12th off the middle Atlantic coast, where it joined high area No. I, as above explained.

VII.—On the 12th the barometer rose in Saskatchewan and the central highest pressure moved southeastward over Manitoba and Lake Superior, and disappeared over the lower Lake region on the 15th.

VIII.—This appeared on the 17th as an offshoot from high area No. VII, reinforced by the flow of air from the northward over Saskatchewan and Athabasca. On the 17th, p. m., pressure was highest in Montana, but on the 18th, a. m., in Manitoba; evidently the flow of cold air from the British Possessions had a preponderating influence in the formation of this high area. On the 18th, p. m., it extended as a ridge from Nebraska northeast to Hudson Bay, and the 19th, a. m., stretched still further south into Texas, while the central highest pressure in Minnesota remained unchanged. During the next twenty-four hours pressure diminished, but the ridge, as such, remained, with but slight change. During the next few days pressure rose in the Canadian Provinces from the Atlantic to the Pacific, and a general area of high pressure seems to have descended and spread eastward and westward over this region. High area No. VIII became gradually transformed and obliterated without any special movement of its center. In connection with high area No. VIII, special warnings were issued as follows: 19th, 11 a. m., frost warnings for Ohio and West Virginia.

IX.—On the 19th pressure rose over the Gulf of St. Lawrence and Maritime Provinces, and was highest on the 20th, p. m., 30.50, at Chatham, after which this area gradually diminished in pressure without any special movement. The steady northeasterly winds over the Middle States, New England, the Maritime Provinces, and St. Lawrence Valley indicate that we have here to do with cold air flowing southward over Labrador and neighboring regions, and deflected toward the southwest by the presence of low pressure in the Ohio Valley, the Lake region, and Atlantic States; the resistance offered to the movement of this air by the land surface

caused it to accumulate and by so doing increase the barometric pressure to the degree indicated by the high pressure at Chatham. Similarly the flow of air southward over Hudson Bay must have been followed by an accumulation and a high pressure in the regions to the southward, as is often shown by the observations in Manitoba, the Lake region, and St. Lawrence Valley. The general high pressure prevailing in these regions from the 20th to the 23d is thus the result of the effort of the northerly winds to flow southward toward the low pressure in the Ohio Valley and the Atlantic States.

X.—On the 22d pressure rose over the Rocky Mountain plateau region, possibly in continuation of the rising pressure that had been prevailing from the northward. By the 24th, p. m., pressure had diminished to normal values, or below, at the Rocky Mountain plateau stations and high area No. X had no further movement.

XI.—On the 26th, a. m., pressure rose in Saskatchewan and the central highest pressure moved slowly southeastward, reaching Iowa by the 28th, a. m., and western Virginia the 29th, a. m., after which it entirely disappeared.

In connection with high area No. XI, special warnings were issued as follows: 27th, 10.30 a. m., frost warnings to Milwaukee and Detroit for Wisconsin and lower Michigan; 28th, 10.30 a. m., frost warnings to Cincinnati, Columbus, Sandusky, Cleveland, and Parkersburg; 28th, 12 m., frost warnings to Buffalo, Rochester, Oswego, Indianapolis, Detroit, Louisville, Pittsburg, and Toledo.

XII.—On the 30th, a. m., pressure was highest in Minnesota, and during the next twenty-four hours this area spread southward, but the center moved westward across Minnesota and by the 31st, p. m., it was in western Nebraska. This western movement was undoubtedly in response to the development of the trough of low pressure that was then extending from British Columbia to the head of the Gulf of California.

#### LOW AREAS.

I.—This was a continuation of No. XVII of April, and on the 1st, a. m., extended from Iowa northeastward over Lake Superior, while an extensive area of high pressure was advancing over the Pacific coast and Rocky Mountain region. On the 1st, p. m., this low area was apparently central in the Lake region, with high winds and rain, but by the 2d, a. m., it had entirely disappeared and, although the lowest pressure was now central at the mouth of the St. Lawrence, it does not seem proper to consider that there had been any such rapid northeastward movement; on the contrary, it is more probable that the low area of the 1st was but the southern end of a long trough that rapidly filled up. This southern end reappeared on the 2d, p. m., as a storm center in the Bay of Fundy while pressure had risen over the Lake region. This series of depressions in Wisconsin, the St. Lawrence, and the Bay of Fundy have every appearance of having been caused by fleeting disturbances in the upper atmosphere that made themselves felt temporarily at the earth's surface; they represent a portion of a series of disturbances that extended from the tropical Pacific northeastward over Lower California, Mexico, the southern plateau, and the Lake region, forming a broad depression between the high pressures of the Atlantic and Pacific.

In connection with low area No. I, signals for high winds were ordered as follows: 1st, 2.05 p. m., cautionary southeast at Marquette and Saginaw Bay section; 1st, 8 p. m., cautionary northwest, Sault Ste. Marie; 2d, 11 p. m., cautionary southeast, Chicago, Milwaukee, and Green Bay; 3d, 8 a. m., cautionary southeast, Sault Ste. Marie; 3d, 11.20 a. m., cautionary southeast, Marquette.

In connection with the same area special warnings were issued as follows: 2d, 10.40 a. m., severe local storms, to observers in Kansas; 2d, 10.50 p. m., severe local storms, to

observers in Springfield, Ill., Cairo, Columbus, Mo., Springfield, Mo., Sioux City, Dubuque, Davenport, and Keokuk.

II.—This number is given to the area of low pressure that frequently extended northeastward from the Pacific over Arizona; its sudden appearance on the 1st, p. m., as on many other occasions, seems, at first thought, to be in part an illusion resulting from the methods of reduction of high stations to sea level, but the fact that the winds and the areas of high pressure immediately moved in toward this depression shows that a low pressure was actually present. The cold northerly wind on the west side of the trough and the warm southerly on the east side exaggerate the slight pressure gradient from which they originated in the manner so clearly explained by Peelin (Smithsonian Report, 1877, p. 465). The center of this trough is probably south and west of Yuma, but that station usually shows the lowest pressure within this trough, as far as shown by the U. S. Weather Maps. The location of low area No. II is, therefore, placed at Yuma, and the lowest pressures at that station occurred on the 2d, a. m., 29.72; 5th, p. m., 29.76; 6th, p. m., 29.70; 8th, p. m., 29.62; 9th, p. m., 29.60; 11th, p. m., 29.78; 14th, p. m., 29.76; 17th, p. m., 29.76; 18th, p. m., 29.74.

The numerous barometric oscillations at Yuma have an intimate correlation with those in Washington and British Columbia. When the high area on the Pacific moves bodily westward the pressure falls on the western slope from Vancouver Island to the Gulf of California, and the fall of pressure takes place either simultaneously at the north and the south, or first at the northern, or first at the southern region, according as the high area retreats westward more or less symmetrically with reference to the Pacific coast. Such oscillations occur both in winter and summer, but in the former the eastward movement, with the accompanying rise of pressure on the Pacific coast, combines with the local rise of pressures due to low temperatures over the Rocky Mountain plateau, while in the summer time the westward movement and the resulting fall of pressure on the Pacific coast combine with the low pressure due to the high temperatures; the result is that the high pressures during winter and the low pressures during summer constitute the most prominent phenomena and tend to attract special attention.

III.—Pressure was lowest at Edmonton on the 2d, p. m., with westerly winds, and the center of this depression was probably further north. The maps of the 4th and 5th show a steadily increasing area of low pressure extending from this region south and east and, undoubtedly, also extending further north; finally the southern end of this extensive area was, on the 6th, p. m., central near Lake Superior, and by the 8th, p. m., it was central in southern Labrador, the greater part of the depression being far north of our weather maps and moving nearly due eastward.

In connection with low area No. III signals for high winds were ordered as follows: 5th, 9.55 a. m., cautionary southwest, Detroit and Saginaw Bay section; 5th, 11.10 a. m., cautionary southeast, lakes Michigan and Superior (except Duluth and Ashland section), Alpena, and Red Wing; 5th, 11.10 a. m., cautionary northeast, Duluth and Ashland section; 5th, 1.50 p. m., cautionary southeast, Port Huron, Toledo, Sandusky, and Cleveland; 5th, 10.50 p. m., cautionary southwest, Erie to Oswego and section; 5th, 10.50 p. m., change to southwest at Port Huron, Toledo, Sandusky, and Cleveland; 5th, 11.00 p. m., storm southeast from Breakwater to Boston and section; 6th, 9.50 a. m., change to cautionary southwest at Red Wing, lakes Superior and Michigan, and Alpena; 6th, 9.50 a. m., continue cautionary southwest at Detroit and Saginaw Bay section; 6th, 10.40 a. m., storm southeast at Portland and Eastport; 6th, 11.30 a. m., storm southwest at Baltimore, Norfolk and section, Fort Monroe, and West Point; 6th, 9.50 p. m., change to cautionary northwest at lakes Superior,

Michigan, and Huron, and Red Wing and Detroit; 6th, 9.50 p. m., continue cautionary southwest from Toledo to Oswego; 6th, 9.50 p. m., change to storm southwest from Breakwater to Boston and section.

IV.—This depression appeared on the 7th, p. m., in Alberta, pressure being lowest at Calgary. The depression extended southeastward over the Rocky Mountain plateau, and by the 8th, p. m., was central in northwest Nebraska, while pressure was equally low at Yuma. On the 9th, p. m., the northern depression was north of Lake Superior, but a trough extended thence south-southwest into Texas, and high area No. VI was central in Idaho. The low pressure now moved northeastward beyond our stations.

In connection with low area No. IV signals for high winds were ordered as follows: 7th, 9 a. m., change to storm southwest at Alpena; 8th, 10 a. m., cautionary northwest at Sault Ste. Marie; 9th, 9.40 a. m., cautionary southeast at Milwaukee and section, Green Bay and Ashland sections, and Houghton section; 9th, 10.30 a. m., cautionary southeast at Red Wing and Lake Michigan, except Milwaukee and section; 9th, 11 a. m., cautionary northeast at Duluth, Marquette, and Sault Ste. Marie; 10th, 9.45 a. m., cautionary southwest at Detroit and Saginaw Bay section; 10th, 10.30 a. m., change to cautionary northwest, Lake Michigan, Alpena, Sault Ste. Marie, Marquette, and Houghton section; 10th, 10.40 p. m., cautionary southwest from Toledo to Oswego; 11th, 9.40 a. m., cautionary southeast, Ashland section; 11th, 11 a. m., cautionary southeast at Red Wing; 11th, 11 a. m., cautionary southwest from Alpena to Duluth, except Ashland section; 11th, 5 p. m., change to cautionary southeast at Alpena.

V.—On the 11th, a. m., pressure was falling from the Gulf of California northward into Canada, and this condition continued until an extensive depression covered the Rocky Mountain plateau and northern slope, slowly developing until, on the 15th, a. m., it may be described as a well-marked area of low pressure with its center in southeastern Montana. By this time pressure had begun to rise on the Pacific coast, and an area of high pressure had also descended southward from Hudson Bay to the lower Lake region, where it was central on the 15th, p. m. While low No. V thus slowly developed over the Rocky Mountain region another depression, low No. VI, was moving northward on the Atlantic, and by the 15th, p. m., was central near Newfoundland and Cape Breton. The descent of high area No. VIII, from Hudson Bay, will, by some, be considered as a mechanical result of the interference of the two systems of upper and lower currents circulating about low No. V and low No. VI, but this elementary theory will explain but a small part of the complex phenomena that attended the formation and movement of these areas of low pressure. Area No. V began its eastward movement on the 15th, and by the 16th, p. m., had reached the eastern limit of South Dakota; by the 17th, p. m., it was central at the southern end of Lake Michigan, and northerly gales prevailed in the upper Lake region. It now began to expand as a long oval, turning northeast and southwest, and by the 18th, a. m., the isobar of 29.55 included lakes Erie and Ontario. By the 18th, p. m., pressure had fallen throughout the Atlantic coast region, while increasing northerly gales prevailed over the Lake region; the area of lowest pressure included three or more centers and systems of whirling winds, respectively, in eastern Ohio, eastern Pennsylvania, and southeastern Virginia. By the 19th, a. m., the center of the barometric depression and the cyclonic system of winds was in the southeastern portion of West Virginia, and the 19th, p. m., it was in the eastern portion of North Carolina. This rapid motion southward was evidently due to the influence of the Allegheny Mountains, and is paralleled by the influence of the Rocky Mountains on the movements of low areas in their neighborhood across that range. During the 20th

the winds diminished in the interior and barometric pressure gradually rose until, by the 21st, p. m., this disturbance had disappeared without any further eastward motion. During the four days from the 17th to the 21st, high area No. VIII had extended eastward over the Canadian Provinces, and by the 21st, a. m., covered the region north of the Lakes and New England. But it is evident that some condition favorable to the perpetuation of low No. V was absent and the movement of the cold air southward not only filled up this depression, but counteracted the tendency to the formation of others until the 23d, p. m., when a feeble depression, No. VII, began to form in Virginia.

In connection with low area No. V signals for high winds were ordered as follows: 13th, 9.40 a. m., cautionary northeast at Duluth; 14th, 8 a. m., cautionary southeast at Alpena; 14th, 11.05 a. m., cautionary southeast at Marquette and Sault Ste. Marie; 15th, 4.18 p. m., cautionary southeast, Lake Michigan; 15th, 10.30 p. m., cautionary northeast on Lake Superior, Red Wing, and Alpena; 15th, 10.30 p. m., cautionary southeast on Lake Erie and at Saginaw Bay section and Port Huron; 16th, 10.40 a. m., cautionary southeast on Lake Ontario; 16th, 4.30 p. m., continue cautionary southeast on Lake Michigan; 16th, 11 p. m., change to cautionary southeast on Lake Superior, at Red Wing, and Alpena; 17th, 9.40 a. m., change to cautionary northeast at Ashland section; 17th, 9.50 a. m., change to cautionary northeast at Duluth; 17th, 10.50 a. m., cautionary southeast, Saginaw Bay section, Port Huron, and Lake Erie; 17th, 11.15 a. m., cautionary southeast at Milwaukee, Green Bay and section; 17th, 5.35 p. m., storm northeast at Port Huron; 17th, 8 p. m., cautionary northwest at Alpena; 17th, 8 p. m., cautionary northeast at Sault Ste. Marie; 17th, 10.10 p. m., cautionary southeast on Lake Ontario; 17th, 10.10 p. m., storm northwest on Lake Michigan; 18th, 8 a. m., cautionary northwest at Marquette; 18th, 9.20 a. m., cautionary northwest, Ashland section and Houghton section; 18th, 9.50 a. m., storm northwest at Alpena; 18th, 11 a. m., change to storm northwest, Lake Erie and Saginaw Bay section; 18th, 9.35 p. m., continue storm northwest on Lake Michigan; 18th, 9.38 p. m., continue cautionary northeast at Sault Ste. Marie; 18th, 10 p. m., change to northwest at Port Huron; 18th, 10.10 p. m., change to cautionary northeast on Lake Ontario; 18th, 10.30 p. m., storm northeast from Sandy Hook to Eastport; 19th, 9.44 a. m., change to cautionary northwest, Milwaukee and Green Bay section; 20th, 10 a. m., cautionary northeast, all lakes, except at Duluth and Ashland section; 20th, 10.40 a. m., storm northeast at Eastport and Portland; 20th, 10.10 p. m., continue signals from Breakwater to Boston and section; 21st, 9.40 a. m., continue cautionary northeast at Milwaukee and section, Green Bay and Houghton sections; 21st, 10.20 a. m., continue cautionary northeast at Sault Ste. Marie and Marquette and on lakes Ontario, Erie, Huron, and Michigan, except Milwaukee and section; 21st, 10.20 a. m., cautionary northeast at Grand Haven.

In connection with the same area special warnings were issued as follows: 15th, 11.15 p. m., severe local storms, to States of the middle and lower Missouri Valley and western Illinois; 16th, 11 a. m., severe local storms, to Chicago, Cairo, Keokuk, Indianapolis, Des Moines, Kansas City, Columbia, St. Louis, and Dubuque; 17th, 11 a. m., severe squalls on Lakes and local storms, to Alpena, Grand Haven, Milwaukee, Chicago, Detroit, Davenport, Dubuque, and Port Huron; 18th, severe gales indicated on the coast Saturday, to Secretary Maritime Exchange in New York and Philadelphia.

VI.—This depression first appeared on the 13th, a. m., in the northern portion of New Brunswick and its early history is unknown, although it was apparently then moving southeastward and was central in Labrador. On the 14th, a. m., it was apparently north of Newfoundland, but the pressure con-

tinued falling in Newfoundland, New Brunswick, and Nova Scotia, until the 15th, p. m. The history of this low area belongs to the North Atlantic meteorology.

VII.—Although this area is charted as beginning on the 23d, p. m., in Virginia, yet there was a previous history that may plausibly, at some time hereafter, be shown to have had an intimate bearing upon its development. On the 18th pressure was low from the Gulf of California to Washington, and on the 19th a special depression appeared in British Columbia; this extended southeastward, diffusing itself over a large area without filling up; on the 21st, a. m., it was central in Wyoming, and on the 22d, p. m., a depression appeared extending from Arizona to Texas, which by the 23d, p. m., had extended its influence eastward into Louisiana and northeastward toward Virginia. On the 23d, p. m., the upper atmosphere contributed a falling pressure over the middle and south Atlantic States, while the lower atmosphere contributed rain and cloud over these States and the Lake region; this combination was favorable to the formation of a special cyclonic depression, No VII, central in southern Virginia on the 23d, p. m. The central barometric pressure fell steadily until the 25th, a. m., when it was central in southern New Hampshire; high winds prevailed on the 24th on the New England coast. The cyclonic system was partly broken up on the 25th as the center moved eastward and disappeared south of Nova Scotia.

In connection with low area No. VII signals for high winds were ordered as follows: 24th, 10.30 p. m., storm northeast from Narragansett section to Portland; 25th, 10.30 a. m., storm northeast at Eastport; 25th, 8.40 a. m., cautionary southwest Woods Holl section.

VIII.—The quiet condition of the atmosphere during the first part of May over the United States was not seriously disturbed until the 25th, on which day a trough of low pressure suddenly extended from British Columbia southward to the Gulf of California, and heavy southerly winds, with rain, prevailed in northern California. This great change can only be attributed to a sudden change in the movements and pressures in the layer of air high above the western slope of the Rocky Mountains which, apparently, suddenly acquired a

rapid motion from the southeast, and the area of rain moved northward, reaching Montana by the 26th, p. m., at which time the lowest pressure was central in British Columbia. This depression moved slowly eastward and disappeared on the 29th, a. m., in Saskatchewan.

IX and X.—On the 26th, a. m., a slight depression is charted in South Dakota as an eastern branch of the large area connected with No. VIII. This depression moved eastward into Iowa, where it really constituted a trough between the cold northerly and warm southerly winds. On the 27th it moved further east over Lake Huron, preserving the same trough-like character; this original trough disappeared on the 28th in Ontario, but a second trough, No. X, formed on the 28th, a. m., in West Virginia, which moved northeastward over New Jersey and disappeared in eastern Massachusetts on the 29th, a. m.

In connection with low area No. IX, signals for high winds were ordered as follows: 27th, 10 a. m., cautionary northwest at Chicago, Grand Haven, and Mackinaw sections; 27th, 5 p. m., cautionary northwest at Sault Ste. Marie; 11.10 p. m., cautionary northwest at Alpena.

XI.—On the 30th pressure again fell, as in the previous case, from the Gulf of California to British Columbia, but was lowest in Idaho, so that neither wind nor rain on the California coast was notably severe. By the 31st, p. m., a distinct narrow trough of low pressure extended from Yuma to Edmonton, the further history of which belongs to the month of June.

XII.—On the 30th pressure rose over the Lake region but fell in the south and middle Atlantic States, so that by the 30th, p. m., a moderate depression was near Lynchburg; this moved slowly northeastward over New Jersey and Cape Cod, with steadily increasing winds and falling pressure, constituting a severe local storm, whose subsequent history belongs to June.

In connection with low area No. XII, signals for high winds were ordered as follows: 31st, 9.40 a. m., storm northeast from Sandy Hook to Boston and section; 31st, 11.10 a. m., storm at Portland, Me.; 31st, 10.50 p. m., storm northeast at Eastport.

## NORTH ATLANTIC METEOROLOGY.

[Pressure in inches and millimeters; wind-force by Beaufort scale.]

The normal barometric pressure for May over the North Atlantic Ocean, as deduced from international simultaneous meteorological observations taken at Greenwich noon, and not reduced to standard gravity, is highest, 30.20 to 30.22 (767 to 768), in a small oval between N. 26° and N. 35°, and W. 27° and W. 34°; a corresponding region of high pressure exists over the Pacific Ocean in N. 20° to N. 40°, and west of W. 130°. The region of lowest pressure, 29.85 (758), over the North Atlantic Ocean is an oval that includes Iceland, Jan Mayen, and Bären Island and touches North Cape on the east and Greenland on the west; the lowest pressure in the Pacific Ocean, 29.70 (755), extends from Kamchatka eastward through the Aleutian Islands. The isobars of the Northern Hemisphere for May show a decided diminution in the pressure over the northern portion of North America up to the Arctic circle and beyond.

As compared with April the normal pressures in May are lower throughout the United States, the Hudson Bay region, northern Greenland, the whole of Asia, and the western portion of the Pacific; the pressures are higher over the Atlantic Ocean and Europe, as also over the central Pacific and eastward into the British Possessions. There is evidently a continued tendency to the formation of a trough of low pressure

extending from the north pole southward over Hudson Bay and southwest over the Gulf of California, dividing the areas of rising pressure over the Atlantic and Pacific.

The normal zone of maximum frequency of paths of storm centers passes from China, at N. 30°, northeast through Japan and Bering Sea to N. 56°, W. 156°; thence southeast into Utah and Colorado at N. 42°, W. 100°; thence northeast over the Lake region and Newfoundland, the Atlantic, and either north of Scotland to the coast of Norway at N. 60°, E. 10°, or else southeastward into Europe, reaching N. 45°, E. 20°. The maximum number of storm centers passing over any quadrilateral of 5° in latitude and longitude is 3.4 annually in the region between the Lakes and the mouth of the St. Lawrence; a corresponding maximum of 2.2 occurs in the neighborhood of Scotland, and one of 2.3 in southern Japan.

The normal rate of progress of storm centers during May is 25 miles per hour in the United States, 16 miles over the Atlantic, 18 miles in Europe, 24 miles in the China and Japan seas, and 20 miles in Bering Sea.

In general it will be noticed that the storms that continue as cyclonic whirls for any length of time in the Northern Hemisphere have areas of predominating high pressure on